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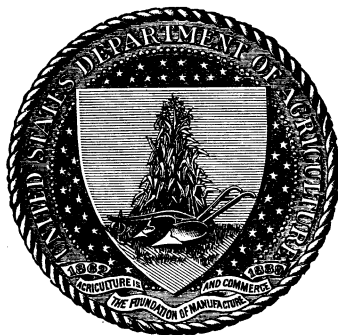
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# SPRAYING FOR FRUIT DISEASES.

BY

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## LETTER OF TRANSMITTAL.

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U. S. DEPARTMENT OF AGRICULTURE,  
DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY,  
*Washington, D. C., March 17, 1896.*

SIR: I have the honor to transmit herewith for publication a Farmers' Bulletin on spraying for fruit diseases. The object of this bulletin is to bring together, in concise, practical form, the results of recent investigations and experiments in the treatment of some of the more common fungous diseases of fruits.

Respectfully,

B. T. GALLOWAY,  
*Chief of Division.*

Hon. J. STERLING MORTON,  
*Secretary of Agriculture.*

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# SPRAYING FOR FUNGOUS DISEASES.

## INTRODUCTION.

It is four years since there was published, in Farmers' Bulletin No. 7, a summary of the more important methods of combating some of the destructive diseases of fruits. During this time many improvements have been made in the work, and for this and other reasons it seems desirable to now bring together, in brief, practical form, our present knowledge on the subject. The question as to whether it will pay to spray has long since been answered in the affirmative, so it is not necessary at this time to enter upon any argument in regard to this phase of the subject. It is furthermore not necessary to go into detail as to the relation of spraying to hygiene. Suffice it to say that if the work is properly done no danger whatever to health need be apprehended.

## FUNGICIDES OR REMEDIES FOR PLANT DISEASES.

During the past four years numerous solutions, powders, etc., have been tested, with a view of determining their value as economical, effective, and practical preventives of fungous parasites. While a number of these preparations have given promise of value, none have been found which fill so many requirements as bordeaux mixture and the ammoniacal solution of copper carbonate. Of the two preparations, bordeaux mixture has long been recognized as possessing the most valuable qualities, and it is probably more generally used to-day than all other fungicides combined. The chief points in its favor are, (1) its thorough effectiveness as a fungicide, (2) its cheapness, (3) its safety from a hygienic standpoint, (4) its harmlessness to the sprayed plant, and (5) its beneficial effects on plants other than those resulting from the mere prevention of the attacks of parasites.

So far as we are at present concerned, therefore, it is necessary to consider only the two fungicides in question, setting forth the recent improvements made in preparing and using them.

## BORDEAUX MIXTURE.

All things considered, it is believed that the best results will be obtained from the use of what is known as the 50-gallon formula of this preparation. This contains—

Water.....	50 gallons.
Copper sulphate .....	6 pounds.
Unslacked lime .....	4 pounds.

It has been found that the method of combining the ingredients has an important bearing on both the chemical composition and physical structure of the mixture. For example, if the copper sulphate is dissolved in a small quantity of water and the lime milk diluted to a limited extent only, there results, when these materials are brought together, a thick mixture, having strikingly different characters from one made by pouring together weak solutions of lime and copper sulphate. It is true, furthermore, that if the copper sulphate solution and lime milk are poured together while the latter or both are warm, different effects are obtained than if both solutions are cool at the moment of mixing. One effect of improper and proper mixing is shown in fig. 1. Where the mixture has been properly made there is scarcely any settling after an hour, while the improperly made mixture has settled more than half.

Briefly, the best results have been obtained from the use of the bordeaux mixture made in accordance with the following directions: In a barrel or other suitable vessel place 25 gallons of water. Weigh out 6 pounds of copper sulphate, then tie the same in a piece of coarse gunny sack and suspend it just beneath the surface of the water. By tying the bag to a stick laid across the top of the barrel no further attention will be required. In another vessel slack 4 pounds of lime, using care in order to obtain a smooth paste, free from grit and small lumps. To accomplish this it is best to place the lime in an ordinary water pail and add only a small quantity of water

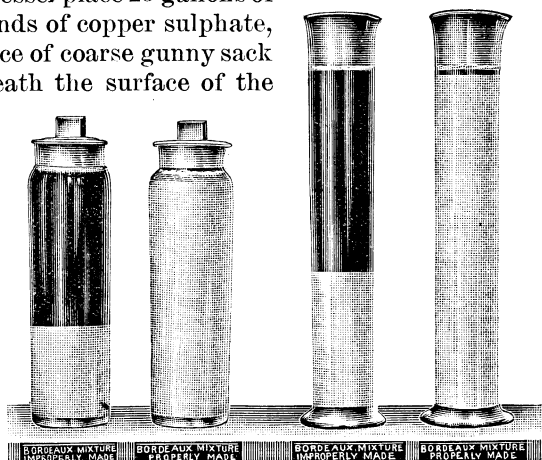


FIG. 1.—Improperly and properly made bordeaux mixture after standing one hour. The properly made mixture has just begun to settle.

at first, say a quart or a quart and a half. When the lime begins to crack and crumble and the water to disappear add another quart or more, exercising care that the lime at no time gets too dry. Toward the last considerable water will be required, but if added carefully and slowly a perfectly smooth paste will be obtained, provided, of course, the lime is of good quality. When the lime is slacked add sufficient water to the paste to bring the whole up to 25 gallons. When the copper sulphate is entirely dissolved and the lime is cool, pour the lime milk and copper sulphate solution slowly together into a barrel holding 50 gallons, as shown in fig. 2. The milk of lime should be thoroughly stirred before pouring. The method described insures good mixing, but to complete this work the barrel of liquid should receive a **final stirring**, for at least three minutes, with a broad wooden paddle.

It is now necessary to determine whether the mixture is perfect—that is, if it will be safe to apply it to tender foliage. To accomplish this, two simple tests may be used. First insert the blade of a penknife in the mixture, allowing it to remain there for at least one minute. If metallic copper forms on the blade, or, in other words, if the polished surface of the steel assumes the color of copper plate, the mixture is unsafe and more lime must be added. If, on the other hand, the blade of the knife remains unchanged, it is safe to conclude that the mixture is as perfect as it can be made. As an



FIG. 2.—Making bordeaux mixture: Pouring together the lime milk and copper sulphate solution.

additional test, however, some of the mixture may be poured into an old plate or saucer, and while held between the eyes and the light the breath should be gently blown upon the liquid for at least half a minute. If the mixture is properly made, a thin pellicle, looking like oil on

water, will begin to form on the surface of the liquid. If no pellicle forms, more milk of lime should be added.

The foregoing directions apply to cases where small quantities of the mixture are needed for more or less immediate use. If spraying is to be done upon a large scale, it will be found much more convenient



FIG. 3.—Testing bordeaux mixture: The saucer or plate method and the knife method.

and economical in every way to prepare what are known as stock solutions of both the copper and lime. To prepare a stock solution of copper sulphate, procure a barrel holding 50 gallons. Weigh out 100 pounds of copper sulphate, and after tying it in a sack suspend it so that it will hang as near the top of the barrel as possible. Fill the barrel with water, and in two or three days the copper will be dissolved.



Now remove the sack and add enough water to bring the solution again up to the 50-gallon mark, previously made on the barrel. It will be understood, of course, that this second adding of water is merely to replace the space previously occupied by the sack and the crystals of copper sulphate. Each gallon of the solution thus made will contain 2 pounds of copper sulphate, and, under all ordinary conditions of temperature, there will be no material recrystallization, so that the stock preparation may be kept indefinitely.

Stock lime may be prepared in much the same way as the copper sulphate solution. Procure a barrel holding 50 gallons, making a mark to indicate the 50-gallon point. Weigh out 100 pounds of fresh lime, place it in the barrel, and slack it. When slacked, add sufficient water to bring the whole mass up to 50 gallons. Each gallon of this preparation contains, after thorough stirring, 2 pounds of lime.

When it is desired to make bordeaux mixture of the 50-gallon formula it is only necessary to measure out 3 gallons of the stock copper solution, and, after thorough stirring, 2 gallons of the stock lime; dilute each to 25 gallons, mix, stir, and test as already described. One test will be sufficient in this case. In other words, it will not be necessary to test each lot of bordeaux mixture made from the stock preparations, provided the first lot is perfect and no change is made in the quantities of the materials used. Special care should be taken to see that the lime milk is stirred thoroughly each time before applying. As a final precaution it will be well to keep both the stock copper sulphate and the stock lime tightly covered.

#### AMMONIACAL SOLUTION OF COPPER CARBONATE.

This preparation, as now generally used, contains—

Water.....	45 gallons.
Strong aqua ammonia.....	3 pints.
Copper carbonate.....	5 ounces.

The copper carbonate is first made into a thin paste by adding a pint and a half of water. The ammonia water is then slowly added, and if of the proper strength, i. e., 26 degrees, a clear, deep-blue solution is obtained, which does not become cloudy when diluted to 45 gallons.

The ammoniacal solution of copper carbonate being a clear liquid, its presence on the leaves, fruit, and other parts of the treated plants is not so noticeable as where the preparations containing lime are used.

In case it is desired to keep the strong solution as a stock preparation, the bottle or jug in which it is placed should be tightly corked.

#### APPLYING FUNGICIDES.

To obtain the best results from the use of a fungicide, it is necessary that it should reach all parts of the plant subject to the attacks of the fungous parasites. Many devices for accomplishing this object have been put on the market in the past three or four years. All these fall

within three principal groups, namely, knapsack pumps, hand pumps, and horse-power sprayers. The knapsack pumps are designed especially for low-growing crops, such as grapes, nursery stock, etc. The

hand-power pumps can be used in a great number of ways, and if strong and durable are probably the most useful of all the various styles of apparatus. The horse-power sprayers are de-

signed to be drawn by one or more horses and operated by the same means. All these machines must be provided with nozzles that will furnish a mist-like spray and at the same time be easy to clean

of any obstruction that may clog the necessarily small opening. There is no form of nozzle that

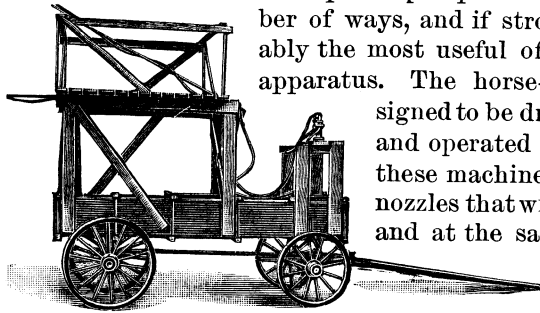


FIG. 4.—Yeomans orchard sprayer, consisting of wagon body holding 300 gallons, pump, and raised platform for the men.

so well fills these requirements as the Vermorel, which is now sold with nearly all spraying outfits.

Where good labor is cheap and the crop is mainly grapes and low-growing plants, the knapsack form of sprayer will probably be found as economical as any apparatus. For orchard work, however, more powerful machinery will be required. Probably the most satisfactory form of apparatus for this kind of work consists of a strong force pump, mounted upon a barrel or hogshead, or probably upon a water-tight box wagon bed, as shown in fig. 4. If mounted on a barrel or hogshead, arrangements will, of course, have to be made to conveniently draw these through the orchards. The horse-power sprayers are nearly all complicated and comparatively expensive; moreover, they can not be used satisfactorily under as many different conditions as the hand pumps mounted on suitable reservoirs. They may be dismissed, therefore, with the statement that it is only in exceptional cases, as, for example, in case of an orchard of several hundred acres on level ground, that it will pay to use them.

With reference to the cost of the several kinds of apparatus mentioned, it may be said that good knapsack pumps, complete in every detail, may now be obtained at from \$10 to \$12 each. The cost of a first-class orchard outfit, such as already described and figured, should not exceed \$25 or \$30. Some kinds, in fact, may be rigged up for even

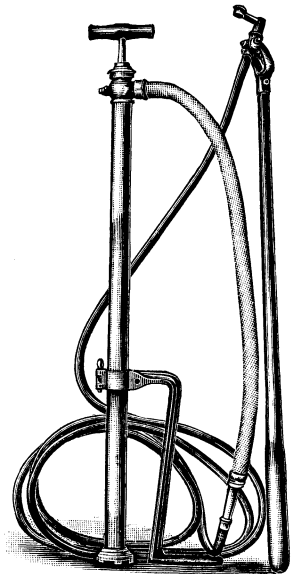


FIG. 5.—Hand pump for miscellaneous work.

\$10 or \$12. The horse-power sprayers will cost all the way from \$25 to \$125 each.

There are many farmers and others who grow a miscellaneous line of fruits, such as a few grapes, pears, apples, etc.; in such cases it is desirable to have an inexpensive and effective apparatus that will answer for the various crops. Such an apparatus is shown in fig. 5. As will be seen, it consists of a small force pump provided with a long piece of discharge hose and a cyclone nozzle. The whole outfit can be purchased and put together for \$5, and it will be found in every way superior to the many forms of syringes on the market. The pump is strong and durable, and although small it will throw a solid stream, the size of a lead pencil, for more than 30 feet. It may be used for trees of all kinds, as well as for vines and low-growing crops.

Passing now to the methods of treatment proper, we may consider first some of the more important diseases of the grape.

#### TREATMENT OF GRAPE DISEASES.

The principal diseases affecting the grape east of the Rocky Mountains are black rot, downy mildew, powdery mildew, and anthracnose.

##### BLACK ROT.

Clean the vineyard thoroughly in the spring, burning all trimmings, rotten berries, dead leaves, etc. When the buds begin to open spray with bordeaux mixture, taking care to wet the new growth and fruit-bearing wood. In ten or twelve days make a second spraying, and follow this with a third as soon as the fruit is well set. In case of rainy weather, additional treatments should be made, at intervals of twelve or fifteen days, until the fruit begins to show signs of ripening. In an average season six treatments are usually necessary to hold the disease in check. In case of much rain, however, eight sprayings would better be given.

As a modification of the foregoing treatment, the first three applications may be made with bordeaux mixture, while for the others the ammoniacal solution may be used. The only advantage in this case is that there is not so much likelihood of having stained fruit at the harvest. If the bordeaux mixture is properly made and applied, there need be little trouble from this source.

##### DOWNY MILDEW.

Downy mildew may be successfully combated by the methods recommended for black rot. In fact, where the two diseases occur together, as they do to a greater or less extent throughout the grape-growing regions of the eastern United States, treatment for the one will answer for the other. In some sections downy mildew and brown rot of the berries, which are due to the same fungus, occur alone, and in such cases the ammoniacal solution will be found an effective remedy. The fungus

of downy mildew and brown rot usually comes on later than the one causing black rot, and for this reason the treatments need not begin so early where downy mildew occurs alone. The first spraying should be made soon after the fruit forms, and other applications should follow at intervals of twelve or fifteen days, as recommended for black rot.

#### POWDERY MILDEW.

This disease seldom does much injury, as it usually comes on late in the season. In regions where it is known to prevail every year, applications of ammoniacal solution will doubtless hold the parasite in check. Flowers of sulphur has also been extensively used; in fact, on the Pacific Coast and in grapes this is almost the only remedy applied.

#### ANTHRACNOSE.

This is quite a serious disease in some sections, and as yet has not yielded as readily to treatment as other grape maladies. The directions given for black rot should be followed in combating this disease, using bordeaux mixture throughout the work. In addition, the vines should be carefully examined before the leaves put out, and whenever the large scars (fig. 6), produced by the fungus, are seen, they should be cut out.

Good results have followed the use of a strong solution of iron sulphate applied to the wood during the winter. The solution may be made by pouring a pint of sulphuric acid upon 25 pounds of iron sulphate, and then slowly adding 50 gallons of water. In no case should this preparation be used after growth starts.



FIG. 6.—Anthracnose of grape leaves, stem, and berries.

#### TREATMENT OF APPLE DISEASES.

Of the several diseases of the apple amenable to fungicidal treatment, scab, bitter rot, and the powdery mildew may be mentioned as probably the most serious.

#### APPLE SCAB.

Use bordeaux mixture, making the first application before the blossoms open. When the flowers are opening spray again, then a third time when the fruit is about the size of a pea. After this two or more treatments should be made, the number depending somewhat on the variety treated, the weather conditions, etc. Ordinarily, five

sprayings will be sufficient to hold the disease in check, but if the season is rainy more should be given. In spraying the apple for scab, the addition of an arsenite to the bordeaux mixture will make it possible to treat the disease in question and the codling moth at the same time. Either paris green or london purple will be found effective if added at the rate of 4 ounces to 50 gallons of the mixture. In case either of these materials is used, a thick paste should first be made by stirring the powder in a pint or a pint and a half of water. The arsenites may be left out of the mixture when the first and second applications are made.

#### BITTER ROT.

This disease may be treated in essentially the same way as scab. As the bitter rot fungus often continues its destructive work after the fruit is harvested, care should be taken in storing to remove all fruit showing evidence of the disease.

#### POWDERY MILDEW.

This disease is injurious to nursery stock, especially to seedlings, which the fungus renders unfit for budding. Applications of the ammoniacal solution, beginning as soon as the leaves unfold and continuing at intervals of twelve days until after budding time, will be found an effective preventive of the disease.

#### TREATMENT OF PEAR DISEASES.

The pear is subject to the attacks of three destructive diseases amenable to fungicides, namely, scab, leaf blight, and cracking. These diseases may be successfully combated by spraying with bordeaux mixture, making at least two applications before the flower buds open, and three others, at intervals of ten or twelve days, after the petals begin to fall.

#### TREATMENT OF QUINCE, CHERRY, AND PLUM DISEASES.

These fruits are all subject to leaf blight, a disease due to different fungi, but amenable to the same treatment. Spray with bordeaux mixture, making the first application when the leaves are half grown and others at intervals of ten or twelve days, until five or six applications in all have been made.

#### FINAL SUGGESTIONS.

It must be constantly kept in mind that the treatments here recommended are preventive, not curative, and for this reason it is important that the sprayings should be made at the proper time and in a thorough manner. It must furthermore be remembered that better results and a saving in both time and money will follow where experienced and trustworthy labor and first-class machinery are used. Poor help, cheap makeshift machinery, and lack of personal supervision on the part of the fruit grower are the chief causes of failure.